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INVENTORY AND VEGETATION CLASSIFICATION OF FLOODPLAIN FOREST COMMUNITIES IN MASSACHUSETTS

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ABSTRACT. Floodplain forests on eleven rivers in Massachusetts were surveyed to determine the variation in vegetation and soils across a range of hydrologic, physiographic, and climatic conditions. Quantitative vegetation data collected from 124 plots at 43 sites were analyzed using TWINSPAN and DECORANA (DCA), and six community types were identified. The six types were: Type I—Riverine island floodplain forests (*Acer saccharinum–Populus deltoides–Acer negundo–Matteuccia struthiopteris* association); Type II—Major-river floodplain forests (*A. saccharinum–P. deltoides–Laportea canadensis* association); Type III—Transitional floodplain forests (*A. saccharinum–Arisaema dracontium* association); Type IV—Small-river floodplain forests (*A. saccharinum–Fraxinus pennsylvanica–Quercus palustris* association); Type V—Alluvial swamp forests (*Acer rubrum–A. saccharinum–Q. bicolor* association); and Type VI—Alluvial terrace forests (*A. rubrum–Carya ovata–Prunus serotina* association). The most common herbaceous taxa throughout all community associations were *M. struthiopteris, L. canadensis, Boehmeria cylindrica,* and *Onoclea sensibilis.* Results of the classification showed variation in floodplain forest vegetation composition among rivers in Massachusetts corresponding to significant differences in soil mottling, soil texture, presence/absence of a surface organic layer, and soil pH.

Key Words: *Acer saccharinum,* community classification, DECORANA, floodplain forest, Massachusetts, ordination, TWINSPAN

Floodplain forests, which develop on alluvial mineral soils within the zone of active flooding of rivers and streams, are considered to be among the most threatened, globally significant wetland community types in New England. Due to their high soil fertility and scenic qualities, floodplain forests have largely been converted to agriculture or lost to housing and industrial development. While several studies have addressed the relationship between floodplain forest vegetation and environmental variables within a single site or river basin in New England (Metzler and Damman 1985; Veneman and Tiner 1990), this study addresses the variability in floodplain forest vegetation and environments across river basins and physiographic regions. The objectives of the current study were to conduct a statewide vegetation classification of floodplain forest communities, to determine the distribution of defined community types across drainage basins and rivers, and to assess differences in environmental parameters among the identified floodplain forest community types.

The Massachusetts inventory and classification work is part of a regional effort to classify floodplain forests by state Natural Heritage Programs and The Nature Conservancy. Results of these projects will provide the baseline community data necessary for future in-depth studies of floodplain forest communities, and for land protection and conservation of these ecologically significant wetland communities.

MATERIALS AND METHODS

Site selection. Potential floodplain forest sites were identified using USGS topographic quadrangles, Natural Resource Conservation Service soil surveys, and color-infrared (CIR) aerial photography. A combination of 1:25,000 scale, leaf-on CIR aerial photography from an unpublished community inventory of the Connecticut River Valley (Motzkin 1993), and 1:12,000 scale, leaf-off CIR aerial photography obtained from the Massachusetts Department of Environmental Protection Wetlands Conservancy Program were used. Potential floodplain forest sites were identified using the following criteria: (1) low, forested sections of greater than 3 ha occurring within 1–2 contour intervals (10–20 ft. elevation) of river's edge; (2) presence of alluvial soils; and (3) evidence of spring flooding and forest vegetation on aerial photography. The Massachusetts Natural Heritage and Endangered Species Program Biological and Conservation Database was also used to locate potential floodplain forest sites by identifying localities of tracked, state-protected rare species known to occur in floodplain forest habitats.

Using the resources and criteria listed above, 144 potential floodplain forest sites were identified in the state. Based on pre-

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Figure 1. Massachusetts' rivers and sub-ecoregions with sites surveyed for floodplain forest vegetation classification. Sub-ecoregions containing survey sites are shaded in grey.

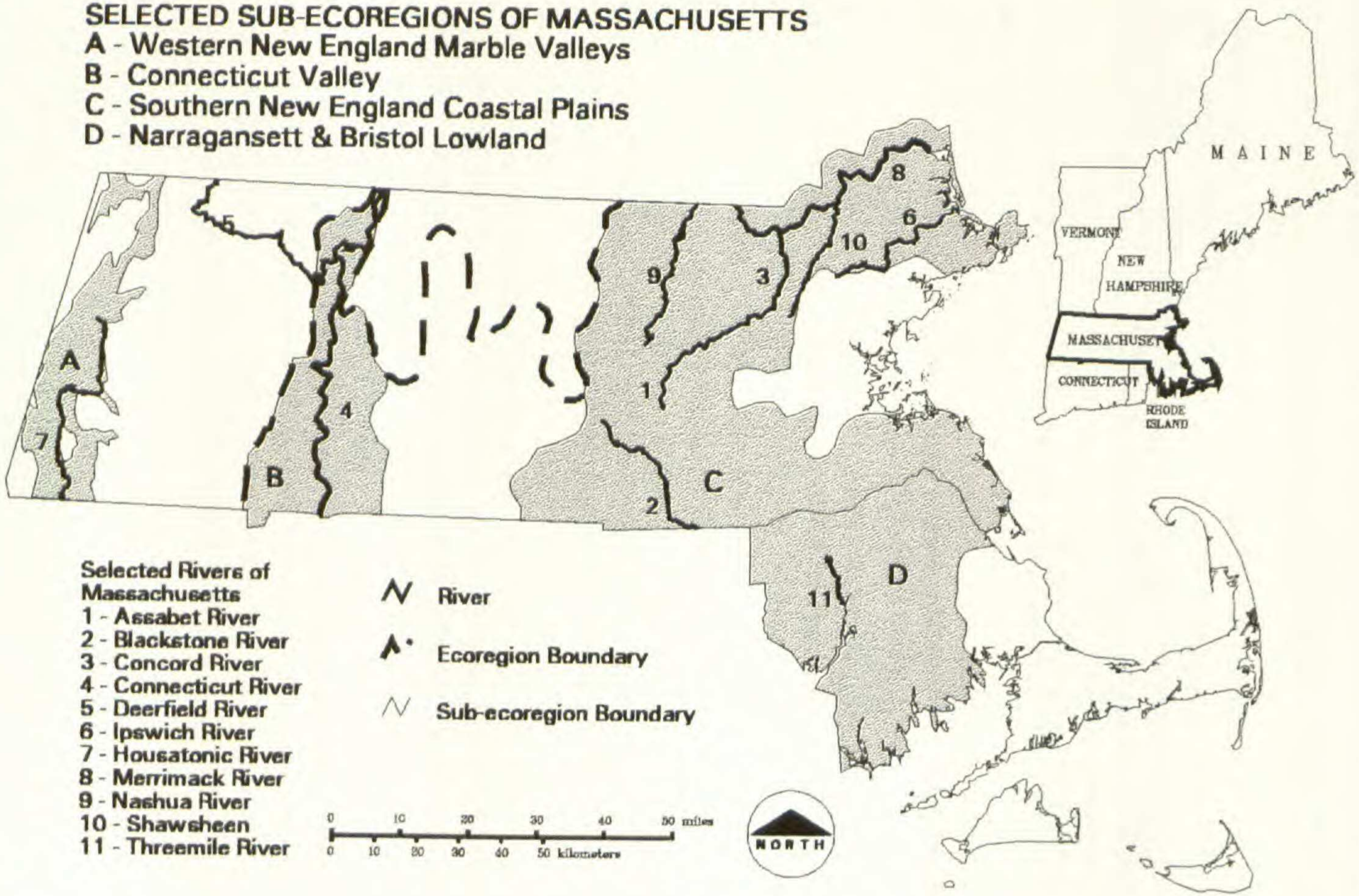
SELECTED SUB-ECOREGIONS OF MASSACHUSETTS
A - Western New England Marble Valleys
B - Connecticut Valley
C - Southern New England Coastal Plains
D - Narragansett & Bristol Lowland
Selected Rivers of Massachusetts
1 - Assabet River
2 - Blackstone River
3 - Concord River
4 - Connecticut River
5 - Deerfield River
6 - Ipswich River
7 - Housatonic River
8 - Merrimack River
9 - Nashua River
10 - Shawsheen
11 - Threemile River
River
Ecoregion Boundary
Sub-ecoregion Boundary
0 10 20 30 40 50 miles
0 10 20 30 40 50 kilometers
NORTH
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND

Table 1. Drainage basins and river sections with sampled floodplain forest communities. Tributaries refer to third order or smaller streams. 50% Exceedance values indicate the discharge of 50% of flows annually, averaged over the period of record (Socolow et al. 1995). Exceedance values are given in cubic feet per second (cfs).

Basin	River	Drainage Basin Area (sq. miles)	Mean 50% Exceedance (cfs)	Number of Sites	Number of Plots
Blackstone	Blackstone	25.6	422	1	1
Connecticut	Connecticut at Thompsonville, CT	9,660	11,000	17	31
	Connecticut tributaries	—	—	7	24
	Deerfield	557	950	7	11
Housatonic	Housatonic at Ashley Falls, MA	465	456	5	13
Ipswich	Ipswich	44.5	37	1	4
Merrimack	Assabet	116	125	1	4
	Concord	400	481	1	4
	Merrimack	4,635	5,110	4	4
	Nashua	435	365	2	13
	Nashua tributary	—	—	1	3
	Shawsheen	36.5	38	2	6
Taunton	Threemile	84.3	113	1	6
			Totals	43	124

liminary field checks of potential sites, 55 were found to be semi-natural forested floodplain sites with evidence of periodic flooding (e.g. floodlines on trees, flood debris, or scoured surfaces) and a relative lack of evidence of human disturbance (e.g. limited clearings or non-native plant species). Quantitative vegetation and environmental data were collected at 43 of the semi-natural forested floodplain sites that were distributed across eleven rivers and four physiographic provinces, or sub-ecoregions (Figure 1).

The eleven rivers ranged in drainage basin area from 25–10,000 square miles, and in mean 50% exceedance values from 30–11,000 cubic feet per second (cfs; Table 1). Fifty percent exceedance values are used as indicators of average river discharge; they indicate the minimum discharge in cfs that 50% of all flows exceed annually, averaged over the period of record (Socolow et al. 1995). Identified floodplain forest sites ranged in size from 1 to 30 ha. Five sites less than the minimum size criterion of 3 ha were included because they either occurred on state-owned land with easy access (3 sites) or occurred on the Merrimack River (2 sites) where potential sampling sites were limited.

Study area. The eleven rivers sampled in this study are located within four subregions of the two ecological regions, or ecoregions, occurring in Massachusetts: the Northern Highlands Ecoregion and the Northeastern Coastal Zone (Figure 1; Griffith et al. 1994). These ecoregions are defined as areas with distinct geology, landforms, soils, vegetation, climate, wildlife, water, and human influences (Griffith et al. 1994).

The Northern Highlands Ecoregion includes all of Massachusetts west of the Connecticut River Valley and the Worcester Plateau in north-central Massachusetts as well as most of northern New England and the Adirondack Mountains in New York (Griffith et al. 1994). It roughly corresponds to the Adirondack–New England mixed forest–coniferous forest–alpine meadow province described by Bailey (1995). The Northeastern Coastal Zone includes eastern and coastal Massachusetts, most of southern New England, and coastal regions of New Hampshire and southern Maine (Griffith et al. 1994). It falls within the central Appalachian broadleaf forest–coniferous forest–meadow province described by Bailey (1995).

The lower Housatonic River runs through the Western New England Marble Valleys subregion of the Northern Highlands Ecoregion (Figure 1). Bedrock in this region, also known as the Berkshire Valley, consists of calcitic and dolomitic marbles and limestones; surface water alkalinity values in the area are high ($>$1000 μeq/L; Griffith et al. 1994). The Connecticut and Deerfield Rivers and the lower reaches of their tributaries are included in the Connecticut Valley subregion of the Northeastern Coastal Zone (Figure 1). The Connecticut Valley is characterized by thick outwash, alluvial, and lake bottom deposits overlaying sedimentary bedrock. Surface water alkalinity values are generally above 500 μeq/L.

The Blackstone, Concord, Assabet, Merrimack, Shawsheen, Ipswich, and Nashua Rivers occur within the Southern New England Coastal Plains and Hills subregion (Figure 1). This is the largest subregion in southern New England and is variable in its topography and bedrock. Bedrock types in the subregion are mostly granites, schist, and gneiss, and surface water alkalinity values are generally lower than in the Connecticut Valley, ranging from less than 50 to 500 μeq/L. The Threemile River occurs in the Narragansett Bristol Lowland subregion (Figure 1). The Narragansett Basin is similar to the Coastal Plains and Hills subregion, but bedrock outcrops are not common, and thick glacial till and outwash deposits cover the area. Surface water alkalinity values are generally between 100 to 300 μeq/L, but several areas have values less than 50 μeq/L (Griffith et al. 1994).

Field methods. Vegetation was sampled in 10 m × 20 m (0.02 ha) rectangular plots placed along transects perpendicular to the river. At most sites, two or more transects were placed at least 50 m apart. Each transect was walked and changes in topography and vegetation were described. A plot was placed within each identified topographic or vegetation unit. In small floodplain forests (≤3 ha), one or two plots were subjectively placed within the "typical" vegetation type(s) and not along transects. The number of plots per site ranged from 1 at small sites to 8 at large sites.

Plots were placed with their long axis parallel to the river. Percent cover of trees (stems >10 cm DBH), shrubs (stems <10 cm DBH), saplings, and vines was visually estimated within each 0.02 ha plot, and percent cover of herbs and seedlings was visually estimated within two 0.0004 ha (2 m × 2 m) square subplots. Herbaceous taxa (<1 m tall) occurring within the 0.02 ha plot, but not within the subplots, were also recorded. Nomenclature follows Kartesz (1994). Percent cover for all taxa was estimated using a modified Braun-Blanquet cover scale with the following cover classes: r (single occurrence), <1%, 1–5%, 6–10%, 11–20%, 21–25%, 26–35%, 36–45%, 46–50%, 51–55%, 56–65%, 66–75%, 76–85%, 86–95%, and 96–100%. The average height and average percent cover of each vegetation stratum were also visually estimated and recorded.

Vegetation data from 124 plots were included in the vegetation classification (Table 1). Eighty-nine plots were surveyed between July and September, 1997, using the methods described above. Existing data from 35 plots collected with equivalent methodologies by other sources were included in the vegetation classification. Those data were: 10 plots from the Deerfield River (Thompson and Jenkins 1992), 16 plots from the Nashua River

(Searcy et al. 1993), 7 plots from the Connecticut River and its tributaries (Motzkin 1993, 1995; Massachusetts Audubon Society, unpubl. data), and 2 plots from the Ipswich River (Massachusetts Audubon Society, unpubl. data).

Environmental data were collected from the 89 plots sampled in 1997. At each plot, one 60 cm deep soil pit was dug and the following soil characteristics were described: depth, soil texture, and color of horizons; depth to mottling; color of mottles; depth of root penetration; and average pH of the mineral soil. The following environmental data were also collected for each plot: topographic position (terrace, levee, level floodplain, depression), height of floodlines, and the number of stumps, and uprooted and snapped trees. Any evidence of disturbance or land use was also noted.

Data analysis. Vegetation cover data were analyzed using two-way indicator species analysis (TWINSPAN) and ordination techniques (DCA) contained in the PC-ORD Version 3.0 statistical package (McCune and Mefford 1997). TWINSPAN (Hill 1979a) was used to identify floodplain forest types, and DCA (Hill 1979b) was used to illustrate the relationship between types. Default settings were used with the following exceptions: Braun-Blanquet cut-levels (0, 5, 26, 51, and 76) were used in the TWINSPAN analysis, and downweighting of rare species was used in DCA. Community types were based on both TWINSPAN and DCA results. Species indicator values for the community types were calculated using the Indicator Species Method of Dufrêne and Legendre (1997) in the PC-ORD Version 3.0 statistical package (McCune and Mefford 1997). Indicator species defined by the Indicator Species Method were used instead of TWINSPAN indicator species to describe community types because: (1) final community types were based on both TWINSPAN and DCA results, and (2) the Indicator Species Method defines indicator species as those species present in the majority of sites belonging to a group, while TWINSPAN defines them as those species that are found mostly in a single group, but not necessarily in the majority of that group's sites (Dufrêne and Legendre 1997). A Monte Carlo technique was used to test for the statistical significance of indicator values.

Species richness, evenness (E), and Shannon diversity index (H′) values were calculated for each plot using the method outlined in the PC-ORD statistical package (McCune and Mefford 1997). Single factor analysis of variance (ANOVA) was used to test if the indices were significantly different among community types. A multi-response permutation procedure (MRPP; Zimmerman et al. 1985) was used to test if defined community types differed significantly in height and total percent cover of the following six strata: emergent canopy, tree canopy, tree sub-canopy, tall shrubs, short shrubs, and herbs.

In order to test for differences in soil characteristics among the defined community types, an MRPP was run on the following variables: presence/absence of soil mottling, depth to mottling (cm), soil texture at 10 cm intervals (sand, loamy sand, sandy loam, and silt loam), presence/absence of a surface organic layer, depth of organic layer, pH, and presence/absence of hydric soil. Hydric soil determination was based on the criteria outlined by the Natural Resource Conservation Service (1994). Individual ANOVA and chi-square tests were used to determine which soil variables were significantly different (at $p < 0.01$) among defined community types. Chi-square tests were used to test for significant differences in presence/absence of floodlines and topographic position.

RESULTS

Vegetation classification. Six vegetation community types were recognized based on the TWINSPAN (Figure 2) and DCA (Figure 3) results. There was general agreement between TWINSPAN groups and DCA output (Figure 3). The six community types described below are primarily based on the TWINSPAN output (Figure 2) with two exceptions. First, twelve plots classified as one type by the TWINSPAN analysis were moved to a different community type based on the DCA results. For example, TWINSPAN classified ten plots as Type I (Figure 2), but the DCA results showed that two plots classified as Type II by TWINSPAN were more closely related to plots classified as Type I. Therefore, Type I is described below as containing twelve plots, and twelve plots were included in the environmental analyses. The second exception is that four plots classified by TWINSPAN were eliminated from the final community types described below and from the environmental analyses because they were found to be distinct species assemblages, unlike all other plots.

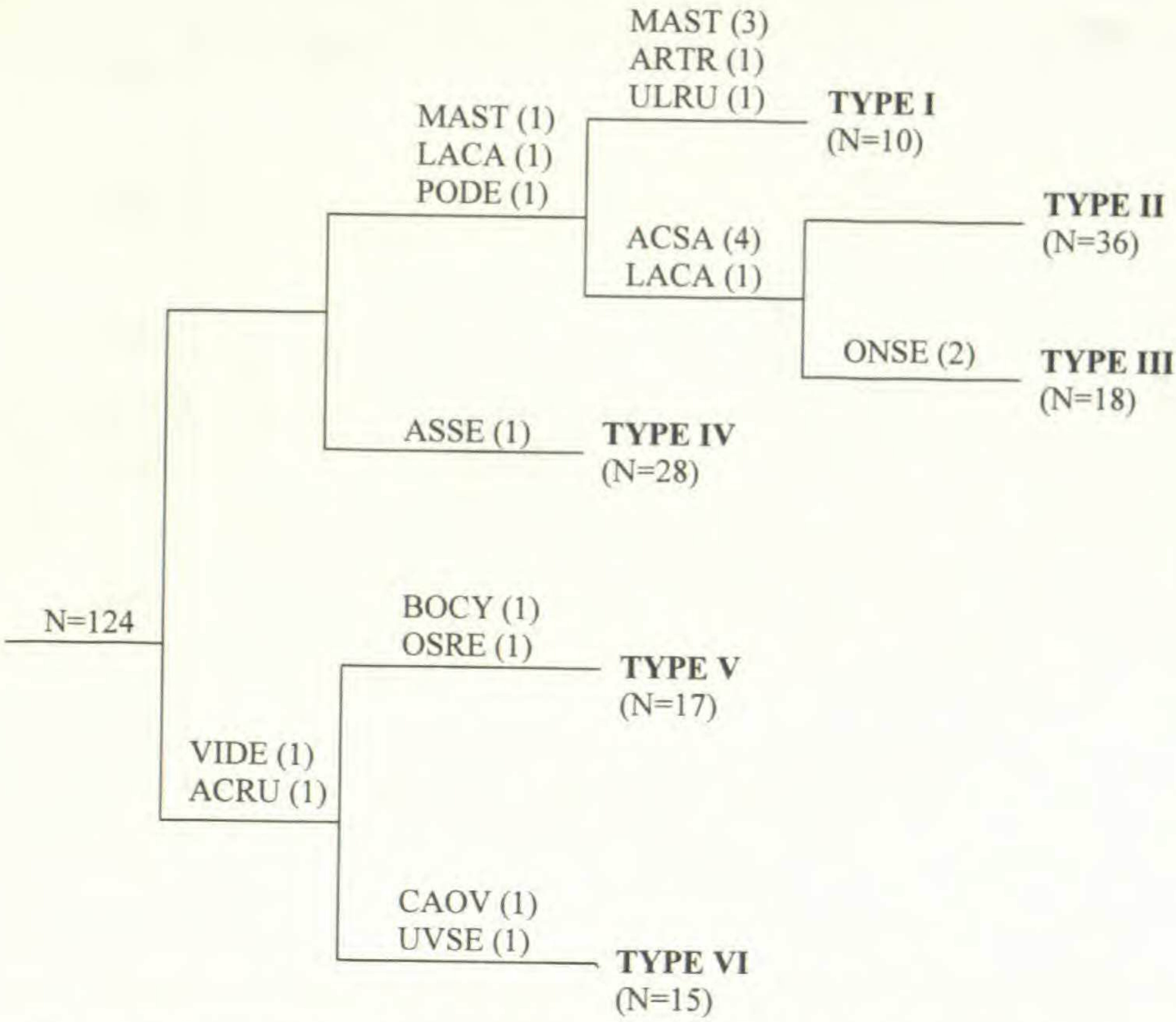

Figure 2. TWINSPAN dendrogram of floodplain forest community types with TWINSPAN indicator species listed at divisions. Species codes follow those listed in Table 2. Numbers in parentheses next to each species indicate the minimum percent cover class for that species in all plots within the community type: (1) 0–4%, (2) 5–25%, (3) 26–50%, (4) 51–75%. Sample sizes refer to the number of plots classified as each type in the TWINSPAN analysis.

The primary division of plots in TWINSPAN was made based on the occurrence of *Acer saccharinum* and *A. rubrum* with Types I, II, III, and IV having *A. saccharinum* dominant in the overstory and Types V and VI having *A. rubrum* dominant (Figure 2). Variation in species composition across DCA ordination Axis 1 ($R^2 = 0.227$) was also associated with a decrease in *A. saccharinum* and increase in *A. rubrum.* Variation in species composition across DCA Axis 2 ($R^2 = 0.127$) was associated with an increase in *Ulmus rubra* and *Impatiens pallida* and a decrease in *Populus deltoides* and *Laportea canadensis.* Axis 3 did not characterize much additional variation in species composition ($R^2 = 0.038$). Plots of Types II and III were closely related in TWINSPAN

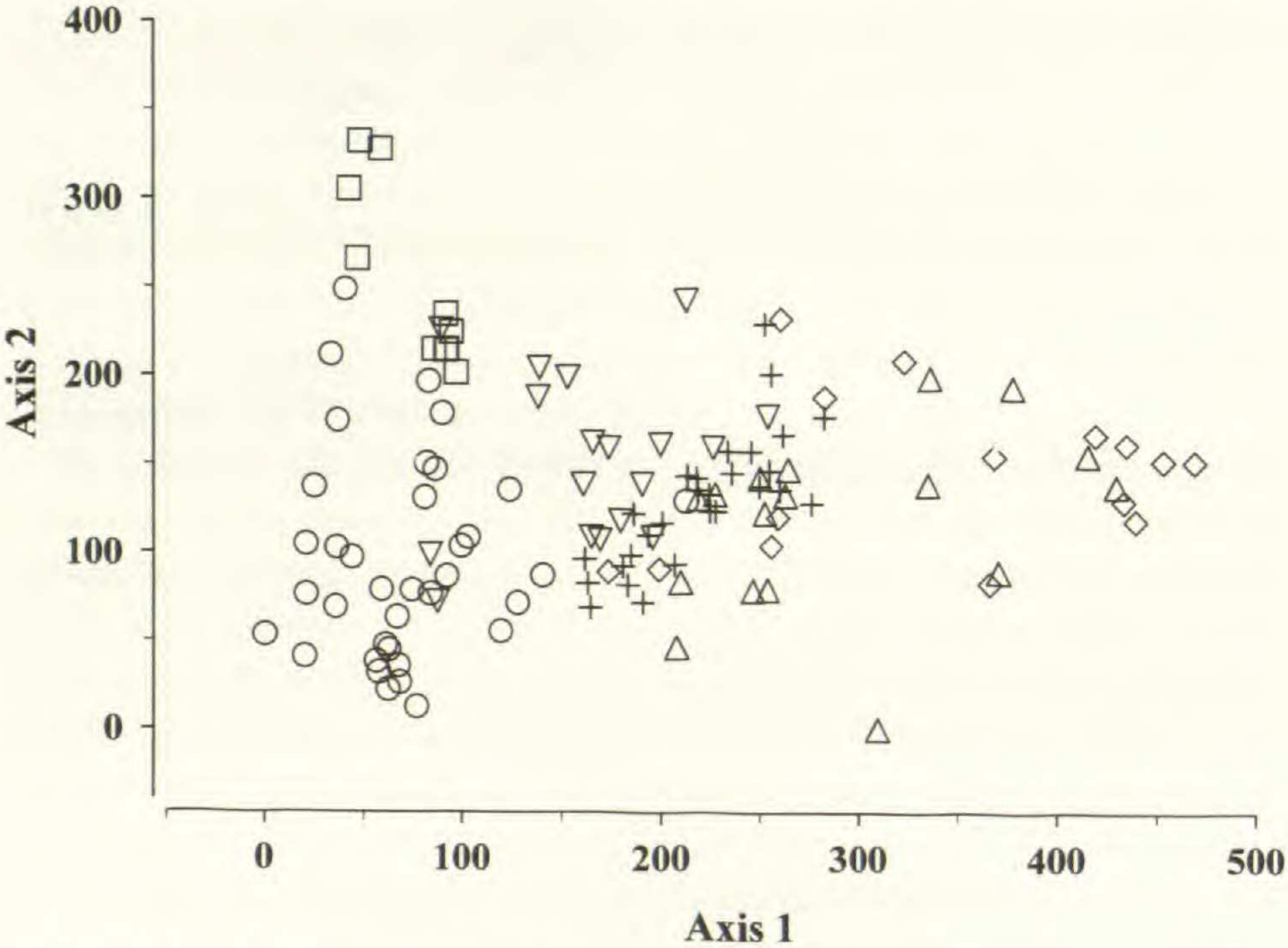

Figure 3. First two axes of the floodplain forest DCA output with plots coded by TWINSPAN group. Squares = Type I, circles = Type II, down-facing triangles = Type III, pluses = Type IV; up-facing triangles = Type V, and diamonds = Type VI.

clustering where they divided at the fourth division (Figure 2), but they were well separated in the DCA analysis along both Axes 1 and 2 (Figure 3).

Two hundred and fourteen vascular plant species were identified in the floodplain forest sampling. A subset of those species with indicator values that were significant ($p \leq 0.05$) and/or greater than 10% are listed in Table 2. Indicator values represent a combination of species relative abundance and relative frequency of occurrence in the identified community types (Dufrêne and Legendre 1997). For example, an indicator value of 10% assumes that the species was present in at least 33% of sites in a community type, and that the relative abundance of the species was at least 33% in one of the community types. If one of the two measures was 100% then the other was at least 10% (Dufrêne and Legendre 1997). Thirty-four taxa with indicator values greater than 20% were plotted according to their DCA axis loading scores for Axis 1 and Axis 2 to illustrate the relationship between species abundance and community types (Figure 4).

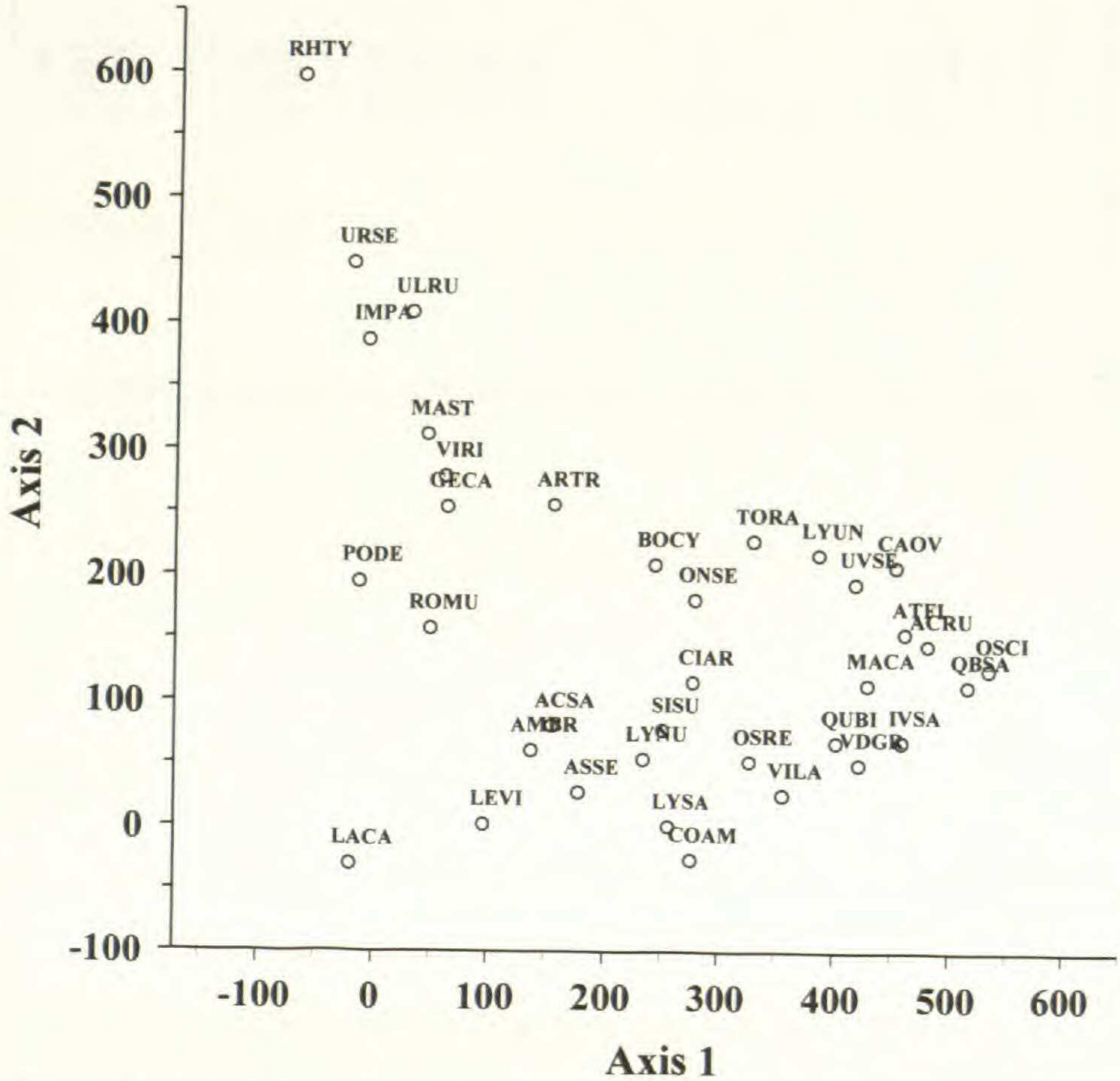

Figure 4. Floodplain forest species with indicator values that are >20% and significant ($p \leq 0.05$) plotted by their axis loading scores for DCA Axis 1 and Axis 2.

Acer saccharinum was the most common tree species encountered and therefore had a low maximum indicator value (22%) for any single community type (Table 2). *Acer saccharinum* attained its highest indicator values in Types II (20%), III (20%), and IV (22%). *Ulmus rubra* was a strong indicator species (46%) for Type I, *Populus deltoides* for Types I and II (24% and 28%, respectively), and *A. rubrum* and *Carya ovata* for Type VI (60% and 49%, respectively; Table 2). Shrubs and saplings were important components of Types I, V, and VI: *Berberis thunbergii, Rhus typhina,* and *Rosa multiflora* had high indicator values in Type I floodplain forests; *Cornus amomum* and *Rhamnus frangula* in Type V; and *Ilex verticillata, Viburnum dentatum,* and *Quercus bicolor* seedlings in Type VI (Table 2; Figure 4).

Table 2. Indicator values and associated p values for floodplain forest taxa listed by community type. * indicates non-native species.

Species Name	CODE	Indicator Values by Community Type						p value
		I	II	III	IV	V	VI	
Acer saccharinum	ACSA	10	20	20	22	14	1	0.035
TYPE I								
Matteuccia struthiopteris	MAST	61	10	15	0	0	0	0
Ulmus rubra	ULRU	46	3	0	0	0	0	0
Impatiens pallida	IMPA	38	2	0	0	0	0	0
Arisaema triphyllum	ARTR	33	6	11	2	0	4	0
U. rubra seedling	URSE	31	0	0	0	0	0	0
A. negundo sapling	ANSA	25	1	0	0	0	0	0
Rhus typhina	RHTY	25	0	0	0	0	0	0
Vitis riparia	VIRI	25	1	7	0	0	0	0.017
**Berberis thunbergii*	BETH	24	0	0	0	0	0	0.006
A. negundo seedlings	ANSE	22	0	0	0	0	0	0.001
**Rosa multiflora*	ROMA	20	2	0	0	0	0	0.027
Geum canadense	GECA	18	3	8	0	0	0	0.031
Acer negundo	ACNE	16	3	0	0	0	0	0.042
**Celastrus orbiculata*	CEOR	10	3	1	3	0	0	0.26
Eupatorium rugosum	EURU	10	6	9	0	0	0	0.437
TYPE II								
Laportea canadensis	LACA	0	84	3	0	0	0	0
Leersia virginica	LEVI	0	29	19	2	2	0	0.058
Populus deltoides	PODE	24	28	1	0	0	0	0.001
Helianthus tuberosus	HETU	0	15	0	0	0	0	0.046

Table 2. Continued.

Species Name	CODE	Indicator Values by Community Type						p value
		I	II	III	IV	V	VI	
**Glechoma hederacea*	GLHE	1	14	1	0	0	0	0.214
**Chelindonium majus*	CHMA	0	13	0	0	0	0	0.073
TYPE III								
Boehmeria cylindrica	BOCY	0	1	32	24	20	0	0.013
Cinna arundinacea	CIAR	0	2	32	1	11	0	0.015
Onoclea sensibilis	ONSE	1	0	27	25	13	7	0.013
Toxicodendron radicans	TORA	0	1	25	9	18	15	0.127
Amphicarpaea bracteata	AMBR	0	2	24	1	0	0	0.002
U. americana sapling	UASA	0	2	20	0	0	1	0.054
**Alliaria petiolata*	ALOF	0	2	18	0	0	0	0.054
Arisaema dracontium	ARDR	0	0	16	0	0	0	0.011
Polygonum virginianum	TOVI	1	2	16	0	0	0	0.026
F. americana sapling	FASA	0	0	14	0	0	0	0.045
A. saccharinum sapling	ASSA	2	4	13	3	1	0	0.21
Platanus occidentalis	PLOC	2	0	12	0	0	0	0.05
TYPE IV								
A. saccharinum seedlings	ASSE	0	1	0	39	8	0	0.001
Sium suave	SISU	0	0	0	29	0	0	0
**Lysimachia nummularia*	LYNU	0	0	0	23	0	0	0.026
F. pennsylvanica seedlings	FPSE	9	0	0	20	0	0	0.016
Cephalanthus occidentalis	CEOC	0	0	0	19	1	0	0.01

Table 2. Continued.

Species Name	CODE	Indicator Values by Community Type						*p* value
		I	II	III	IV	V	VI	
Fraxinus pennsylvanica	FRPE	0	0	1	19	6	1	0.039
Lysimachia terrestris	LYTE	0	0	0	18	0	2	0.012
Quercus palustris	QUPA	0	0	0	18	0	0	0.007
**Myosotis scorpioides*	MYSC	0	0	0	17	0	0	0.043
Cicuta maculata	CIMA	0	0	0	14	0	0	0.035
Leersia oryzoides	LEOR	0	0	0	14	0	0	0.029
Q. palustris seedlings	QPSE	0	0	0	14	0	0	0.055
Phalaris arundinacea	PHAR	0	0	0	13	0	0	0.035
**Polygonum persicaria*	PLRS	0	0	1	13	0	0	0.139
Carex lupulina	CALU	0	0	0	11	0	0	0.065
Carex typhina	CATY	0	0	0	11	0	0	0.079
Lobelia cardinalis	LOCA	0	0	0	11	0	0	0.078
TYPE V								
Osmunda regalis	OSRE	0	0	0	0	53	0	0
Quercus bicolor	QUBI	0	0	0	0	39	4	0
Vitis labrusca	VILA	0	0	0	0	31	0	0
**Lythrum salicaria*	LYSA	0	0	0	6	25	0	0.003
Cornus amomum	COAM	0	0	0	6	24	3	0.013
Lycopus uniflorus	LYUN	0	0	0	0	20	0	0.003
Carex crinita	CACR	0	0	0	9	15	0	0.095
**Rhamnus frangula*	RHFR	0	0	0	3	15	6	0.047
Betula nigra	BENI	0	0	0	4	13	0	0.042
Q. bicolor seedlings	QBSE	0	0	0	0	13	8	0.067

Table 2. Continued.

Species Name	CODE	Indicator Values by Community Type						*p* value
		I	II	III	IV	V	VI	
TYPE VI								
Acer rubrum	ACRU	0	0	0	0	13	60	0
Viburnum dentatum	VIDE	0	0	0	0	16	54	0
Carya ovata	CAOV	0	0	0	0	0	49	0
Ilex verticillata	ILVE	0	0	0	1	0	47	0
Athyrium felix-femina	ATFI	0	0	0	0	1	37	0
Maianthemum canadense	MACA	0	0	0	0	3	37	0
Uvularia sessilifolia	UVSE	0	0	0	0	0	35	0
Osmunda cinnamomea	OSCI	0	0	0	0	0	29	0
Q. bicolor saplings	QBSA	0	0	0	0	0	21	0.003
Tilia americana	TIAM	1	0	0	0	0	19	0.004
P. serotina seedlings	PSSE	0	0	0	0	0	14	0.017
Ulmus americana	ULAM	2	2	2	1	6	12	0.308
Circaea lutetiana ssp. *canadensis*	CIQU	4	1	1	0	1	11	0.206
Parthenocissus quinquefolia	PAQU	3	4	0	3	0	11	0.825
A. rubrum seedlings	ARSE	0	0	0	1	0	10	0.068
Prunus serotina	PRSE	4	0	0	0	5	6	0.511

Variation in abundance of woody vines along DCA Axis 1 was associated with an increase in *Vitis labrusca* and a decrease in *V. riparia* (Figure 4); *V. labrusca* attained its highest indicator value in Type V, while *V. riparia* was most abundant in Type I (Table 2). *Toxicodendron radicans* occurred across all plots, but was most abundant in Types III, IV, V, and VI (Table 2). Variation in herbaceous species composition across DCA Axis 1 was associated with a decrease in *Matteuccia struthiopteris* and *Laportea canadensis* and an increase in *Osmunda regalis* and *O. cinnamomea* (Figure 4). *Boehmeria cylindrica* and *Onoclea sensibilis* had intermediate Axis 1 loading scores (Figure 4) and high indicator values for Types III, IV, and V (Table 2). Variation in herbaceous species composition across Axis 2 was associated with decreasing *L. canadensis* and increasing *Impatiens pallida* and *M. struthiopteris* (Figure 4).

Community structure was similar among floodplain forest types, and the six community types did not differ significantly in the height and total percent cover of vegetation strata (MRPP $p = 0.45$). All types were characterized by a dense, tall tree canopy (20 m mean height, 70% mean cover) above a diffuse subcanopy (7 m mean height, 19% mean cover) and very limited to absent shrub layer (1.5 m mean height, 9% mean cover). The herbaceous cover was dense (80% mean cover) in most plots, and tall (1–2 m) when *Laportea canadensis* or *Impatiens* spp. were dominant (Types I and II; Table 2). Species richness was not significantly different among identified types ($p = 0.217$), but types did differ significantly in species diversity ($p = 0.029$) and species evenness ($p = 0.0004$) with Type VI forests having the highest values for both ($H' = 1.75$, $E = 0.71$).

Environmental parameters. Soil profiles of Types III, IV, V, and VI were typically hydric silt loams with soil mottling, while soil profiles of Types I and II were nonhydric, sandy loams, loamy sands, or sands without soil mottling (Table 3). Soil profiles of Types V and VI usually had a surface organic layer, while soil profiles of Types I, II, and III usually lacked a surface organic layer (Table 3). Soil pH was least acidic in Types I, II, and III (Table 3).

Results of the MRPP of soil variables showed that the observed differences in soil profiles among the six floodplain forest community types were statistically significant ($p = 0.001$). Soil texture, pH, and presence/absence of soil mottles, surface organic layer, and hydric soils were all significantly different ($p < 0.001$) among community types, while depth to mottling and depth of organic layer were not significantly different (Table 3).

Presence/absence of floodlines and topographic position were also significantly different among defined types ($p < 0.001$). Most floodplain plots occurred on level floodplains, except for Type I communities which typically occurred on elevated sections of riverine islands and Type VI communities which occurred on ridges or high terraces (Table 3). Floodlines were visible on tree trunks in 41% of all plots, and they were most common in community Types III and IV (Table 3). Snapped trunks were observed in 34% of all plots, uprooted trunks in 7%, and stumps (cut or beaver-cut) in 16%. When present, there were usually only one or two downed trees per 0.02 ha plot, and downed trees did not appear to be abundant overall in the floodplain forests inventoried.

COMMUNITY TYPE DESCRIPTIONS

Type I—Riverine island floodplain forests (*Acer saccharinum–Populus deltoides–Acer negundo–Matteuccia struthiopteris* association). Type I communities (12 plots at 8 sites) were open-canopy floodplain forests occurring on elevated sections of riverine islands and riverbanks of major rivers with high levels of disturbance. The community type was limited to the Connecticut, Deerfield, and Housatonic Rivers in Massachusetts (Table 4). Plots classified as Type I were most likely to occur at sites where the vegetation in all plots at the site was classified as Type I. Table 5 shows that of the eight sites with plots classified as Type I, five had all plots classified as Type I, three had plots classified as both Types I and II, and one had plots classified as Types I, II, and III. Type I communities were never associated at sites with vegetation classified as Types IV, V, or VI (Table 5). Soils of Type I communities were typically nonhydric, sandy loams without soil mottles and without a surface organic layer. Soil pH ranged from 5.5 on the Connecticut and Deerfield River plots to 8.0 on the Housatonic River (Table 3).

The overstory of Type I communities was a mixture of *Acer saccharinum* and *Populus deltoides*. *Platanus occidentalis* and

Table 3. Environmental data for floodplain forest community types. *Soil texture: S = Sand, LS = Loamy Sand, SL = Sandy Loam, ST = Silt Loam. **Topographical position of plots within floodplain: TR = Terrace, LF = Level Floodplain, LE = Levee, DP = Depression.

Type	Number of Plots	% of Plots with Soil Mottling (mean depth to, in cm)	% of Plots with each *Soil Texture at 10 cm				% of Plots with Soil Organic Layer (mean depth of, in cm)	Mean pH (range)	% of Plots with Hydric Soil	% of Plots with Floodlines (height range in cm)	% of Plots in each **Topographical Position			
			S	LS	SL	ST					TR	LF	LE	DP
I	11	0	0	0	91	9	0	6.6 (5.5–8.0)	0	36 (43–135)	64	27	9	0
II	23	13 (15.7)	5	14	50	31	4 (1.0)	6.3 (4.5–8.0)	0	13 (93–220)	13	61	26	0
III	16	75 (18.3)	0	6	31	63	0	6.2 (4.5–8.0)	38	62 (60–303)	19	75	0	6
IV	16	88 (14.0)	6	6	12	76	35 (5.0)	5.2 (4.5–6.0)	59	69 (44–265)	0	94	6	0
V	17	67 (26.1)	0	6	27	67	67 (5.0)	4.8 (4.5–5.5)	40	47 (45–122)	0	80	7	13
VI	5	60 (17.3)	0	0	40	60	60 (5.3)	5.0 (4.5–6.0)	40	0	60	40	0	0
ALL	87	50 (18.5)	2	5	42	51	23 (4.8)	5.7 (4.5–8.0)	30	41 (43–303)	19	73	10	3

Table 4. Number of plots by each river in the defined floodplain forest community types.

Basin	River	Community Type I	II	III	IV	V	VI
Blackstone	Blackstone						1
Connecticut	Connecticut	9	20	1			
	Connecticut tributaries		1	9	12		2
	Deerfield	2	8	1			
Housatonic	Housatonic	1	3	8			
Ipswich	Ipswich				4		
Merrimack	Assabet				1	2	1
	Concord					4	
	Merrimack				2		
	Nashua				1	3	9
	Nashua tributary				3		
	Shawsheen				2	4	
Taunton	Threemile				3	2	1
	Totals	12	32	19	28	15	14

Fraxinus americana were occasional canopy associates. *Ulmus rubra, A. negundo,* and *Celtis occidentalis* (on the Housatonic River) were common in the subcanopy (Table 2). The shrub/sapling layer was patchy and composed of taxa typical of disturbed areas, including *Rhus typhina, Rosa multiflora, Berberis thunbergii,* and *Celastrus orbiculata. Berberis thunbergii* was observed in this floodplain forest community type more frequently than in any other (Table 2). The herb layer was dominated by *Matteuccia struthiopteris* (most plots had greater than 40% cover) or by a

Table 5. Number of sites with plots of one defined floodplain forest community type that also have plots of other community types.

	Type I	Type II	Type III	Type IV	Type V	Type VI	Total # of Sites with Plots of Type
Type I	5	3	1				8
Type II	3	7	7				17
Type III	1	7	3	1			11
Type IV			1	7	4	3	12
Type V				4	2	3	6
Type VI				3	3	2	5

dense, tall layer of *Impatiens pallida* over *M. struthiopteris. Laportea canadensis* occurred in low amounts but was never abundant. Other common herbaceous taxa were *Eupatorium rugosum, Arisaema triphyllum,* and *Geum canadense. Vitis riparia* was a strong indicator vine (Table 2), and *Parthenocissus quinquefolia* was also common.

Type II—Major-river floodplain forests (*Acer saccharinum–Populus deltoides–Laportea canadensis* association). Type II communities (32 plots at 17 sites) occurred on mainstem sections of the Connecticut, Deerfield, and Housatonic Rivers (Table 4). Plots classified as Type II were most likely to occur at sites with other plots classified as Type II or at sites with plots classified as Type III (Table 5). Type II communities sometimes occurred associated with vegetation classified as Type I, but never with Types IV, V, or VI (Table 5). Soils were predominantly sandy loams without soil mottles (13% of plots had mottles) and without a surface organic layer (only 4% of plots had an organic layer). Soil pH ranged from 4.5 on the Connecticut and Deerfield Rivers to 8.0 on the Housatonic (Table 3).

Acer saccharinum was strongly dominant in the overstory (>60% cover in most plots) mixed with lesser amounts of *Populus deltoides. Ulmus americana* and/or *U. rubra* occurred in the subcanopy. Shrubs were generally lacking. The herbaceous layer was usually dominated by a 1–2 m tall, dense cover of *Laportea canadensis,* and *Matteuccia struthiopteris* was sometimes abundant. *Leersia virginica* was consistently represented, but in low amounts (typically <5% cover). Other common associates were *Cinna arundinacea, Impatiens* sp., *Boehmeria cylindrica,* and *Arisaema triphyllum.* Non-native plant species were usually less abundant than in Type I communities, but *Polygonum cuspidatum* often formed large patches along heavily scoured levees or in areas where the canopy was open. Other common non-native taxa were *Glechoma hederacea* and *Alliaria petiolata.*

Type III—Transitional floodplain forests (*Acer saccharinum–Arisaema dracontium* association). Type III communities (19 plots at 11 sites) occurred on third-order or smaller tributaries of the Connecticut River, on the Housatonic River, and in depressions within Major-river floodplain forests (Types I and II) of the Connecticut and Deerfield Rivers (Table 4). Plots classified as Type III were found associated at sites with plots classified as Types I, II, and IV (Table 5). Type III communities were intermediate in soil texture and drainage between the sandy, well-drained soils of Types I and II and the highly mottled, poorly drained silt loams of Type IV. Soil texture was silt loam or very fine sandy loam. Soils were poorly drained, and 75% of plots had soil mottling. None of the plots had a surface organic layer. The pH ranged from 4.5 to 8.0 (Table 3).

The Type III vegetation association was transitional between Major-river (Types I, II) and Small-river (Type IV) floodplain forest vegetation, and shared taxa with Types I, II and IV (Table 2; Figure 3). In Type III communities, *Acer saccharinum* was dominant in the canopy, but unlike Types I and II, *Populus deltoides* was typically absent. As in Type IV plots, *Fraxinus pennsylvanica* and *Ulmus americana* were present. A shrub layer was lacking; however, saplings of overstory trees were common. Vines were abundant with *Amphicarpaea bracteata* most common. In contrast to Type II plots, *Laportea canadensis* was not dominant, but it was present in low amounts in all plots (5–15% cover). The herbaceous layer was typically an even mixture of *L. canadensis, Matteuccia struthiopteris, Onoclea sensibilis,* and *Boehmeria cylindrica.* Common associates were *Leersia virginica, Arisaema triphyllum, Bidens frondosa, Cinna arundinacea,* and *Impatiens* sp. *Arisaema dracontium* (a state-protected rare species) was associated with this floodplain forest community type and serves as a good indicator species of the type (Indicator value = 16; Table 2; Kearsley 1999).

Type IV—Small-river floodplain forests (*Acer saccharinum–Fraxinus pennsylvanica–Quercus palustris* association). Type IV communities (28 plots at 12 sites) occurred on third order or smaller tributaries of the Connecticut and Nashua Rivers, on smaller rivers of eastern Massachusetts where banks are low and overbank flooding occurs (Ipswich, Assabet, Shawsheen, and Threemile), and on edges of riverine islands of the Merrimack River (Table 4). Vegetation classified as Type IV was sometimes associated at sites with vegetation classified as Types III, V, and VI (Table 5). Soils were a mixture of silt loams and fine sandy loams. Fifty-nine percent of soil profiles were classified as hydric; 88% had soil mottles and 35% had a surface organic layer. The pH ranged from 4.5 to 6.0 (Table 3).

As in Types I, II, and III, *Acer saccharinum* was dominant in the overstory of Type IV communities, but the understory of Type IV communities more closely resembled that of *A. rubrum* Alluvial swamp forests (Type V) and Alluvial terrace forests (Type VI). *Populus deltoides* and *A. rubrum* were both absent in the canopy of Type IV communities. *Quercus palustris* was a common associate in the Connecticut River basin, and *Betula nigra* in the Merrimack River basin. Type IV floodplain forest plots had a more substantial shrub layer than both Major-river (Types I and II) and Transitional (Type III) types, but less than both Types V and VI. The shrub layer of Type IV communities consisted mainly of *Cornus amomum* and *Cephalanthus occidentalis. Fraxinus pennsylvanica* saplings were present in most plots.

There was greater herbaceous diversity in Small-river floodplain forests than in floodplain forest Types I, II, and III. *Onoclea sensibilis* and *Boehmeria cylindrica* were most common, but associates included *Acer saccharinum* seedlings, *Cicuta maculata, Lysimachia terrestris, Sium suave,* and non-native taxa, such as *L. nummularia, Myosotis scorpioides, Rhamnus frangula,* and *Lythrum salicaria.* Four state-protected rare plant species were associated with this community type: *Mimulus alatus* (State Endangered), *Carex typhina* (State Threatened), *C. grayi* (State Threatened), and *Rumex verticillatus* (State Threatened; Kearsley 1999).

Type V—Alluvial swamp forests (*Acer rubrum–A. saccharinum–Quercus bicolor* association). Type V plots (15 plots at 6 sites) occurred along mainstem sections of smaller rivers in eastern Massachusetts (Assabet, Concord, Nashua, Shawsheen, and Threemile; Table 4). Plots classified as Type V were often associated at sites with plots classified as Types IV and VI (Table 5). This type appeared to be wetter and more seasonally inundated than the four *Acer saccharinum* dominated types (Types I–IV). Soils were typically silt loams; 67% had soil mottles and 67% had a surface organic layer. The pH ranged from 4.5 to 5.5 (Table 3).

Vegetation of plots classified as Type V was variable, as indicated by the lack of strong clustering in the DCA analysis (Figure 3). In general, the overstory of Type V plots was characterized by a mixture of *Acer saccharinum* and *A. rubrum* with lesser amounts of *Fraxinus pennsylvanica* and/or *Quercus bicolor.* Unlike Types I–IV, Type V communities had a well-developed shrub layer dominated by *Viburnum dentatum, Cornus amomum,* and the non-native plant *Rhamnus frangula.* As in Type IV communities, the herbaceous layer of Type V communities was characterized by a mixture of *Onoclea sensibilis* and *Boehmeria cylindrica*; however, the herbaceous layer differed in also having *Q. bicolor* seedlings, *Osmunda regalis,* and *Carex crinita.*

Type VI—Alluvial terrace forests (*Acer rubrum–Carya ovata–Prunus serotina* association). Type VI plots (14 plots at 5 sites) occupied upland ridges within Alluvial swamp forests (Type V) and high terraces above the active flood zone. Plots of this type occurred on the Nashua, Assabet, Blackstone, and Threemile Rivers and on high terraces in the Connecticut River basin (Table 4). Vegetation classified as Type VI was often associated with Types IV and V (Table 5). Type VI forests were river influenced and mesic, but they did not appear to experience regular flooding as indicated by the presence of a distinct soil organic layer. Soils were typically silt loams; 60% had soil mottles and 60% had a surface organic layer. The pH ranged from 4.5 to 6.0 (Table 3).

This community type showed the greatest within-group variability in plot composition, as indicated by the point spread in the DCA output (Figure 3). Although the plots were not highly clustered, they were well-differentiated from the other five floodplain forest community types. *Acer rubrum* was dominant in the canopy, and typically mixed with varying amounts of mesic hardwoods including *Carya ovata, Prunus serotina, Ulmus americana,* and *Tilia americana.* As in Type V communities, the shrub layer was well-developed, and *Viburnum dentatum* and *Ilex verticillata* were most common. The herbaceous layer was a species-rich mixture of *Onoclea sensibilis, Maianthemum canadense, Athyrium felix-femina, Osmunda cinnamomea,* and *Uvularia sessilifolia.*

DISCUSSION

The greatest differences in vegetation composition and environmental characteristics among the floodplain forest community types occurred between Types I–III and Types IV–VI. These two groups were well-separated floristically, environmentally, and spatially. Types I–III occurred at sites on the Connecticut, Deerfield, and Housatonic Rivers, and Types IV and V occurred on small tributaries of the Connecticut River or on rivers in eastern

Massachusetts. Type VI occurred on elevated ridges and high terraces across the state, but more data are needed to clarify the distribution of and variation in high-terrace forests statewide.

Vegetation classified as Types I, II, and III often occurred together at a site. Sites with vegetation that was primarily classified as Type II had patches, usually on elevated sections, where *Matteuccia struthiopteris* was dominant (Type I), and depressions where *Boehmeria cylindrica* and *Onoclea sensibilis* were dominant (Type III). Similarly, sites with vegetation primarily classified as Type III had elevated sections dominated by *Laportea canadensis* (Type II). Overlap between community types within a single site also occurred among Types IV, V, and VI. Type IV forests in eastern Massachusetts had *Quercus bicolor* dominant (Type V) in low-lying, wet depressions and mesic, mixed-deciduous patches (Type VI) in elevated areas.

Although Types I–III and Types IV–VI were generally well-differentiated, overlap among defined community types did occur, particularly among Types III, IV, and V. These three types were all characterized by *Boehmeria cylindrica* and *Onoclea sensibilis* in the herbaceous layer, and differences in vegetation composition among the three types was subtle; however, differences in soil profiles and location supported the three types as recognizable associations.

Types I and II were also similar, and the differences observed in vegetation composition appeared to be primarily related to greater disturbance in areas classified as Type I. Riverine islands of the Connecticut and Deerfield Rivers where Type I vegetation assemblages were found had many canopy openings that were created by campers. Abandoned campsites were filling in with *Rhus typhina, Polygonum cuspidatum,* and a mixture of vines, including *Celastrus orbiculata* and *Vitis riparia.* The abundance of *Acer negundo,* which was associated with open, disturbed areas of Ohio floodplain forests (Hardin et al. 1989), was also indicative of greater disturbance in Type I forest plots.

Comparison to other floodplain forest classifications. Type I and II Major-river floodplain forests are similar in vegetation composition to floodplain forests of larger rivers in other New England states. Type I forests correspond to the *Acer negundo–Matteuccia struthiopteris* association described in Vermont, which occurs on sandy loams or open cobbles within the active floodplain of larger rivers. Type II forests correspond to Vermont's *A. saccharinum–M. struthiopteris* association, which occurs on coarse soils of levees of larger rivers (Sorenson et al. 1998). Elsewhere in New England a distinction between the two community types has not been made; however, Types I and II together correspond to the *A. saccharinum–M. struthiopteris–Laportea canadensis* association in New Hampshire (Bechtel and Sperduto 1998), the *A. saccharinum–Eupatorium rugosum* association in Connecticut (Metzler and Damman 1985), and to the *A. saccharinum* temporarily flooded forest alliance described for the eastern United States (Sneddon et al. 1998). Type I also contains elements of the *A. negundo* temporarily flooded forest alliance described for the Southeast which includes early successional vegetation of active floodplains and sandbars with a heavy vine component (Sneddon et al. 1998).

Type III *Acer saccharinum–Fraxinus pennsylvanica–Ulmus americana* floodplain forests correspond to *A. saccharinum/Onoclea sensibilis* floodplain forests described for Connecticut (Metzler and Damman 1985). Similar to Type III forests, *Matteuccia struthiopteris* was the dominant herbaceous taxon on the highest ridges within the community type in Connecticut (Metzler and Damman 1985). Type III forests are also closely affiliated with *A. saccharinum–O. sensibilis–Boehmeria cylindrica* communities occurring on silty soils of lower watersheds and lakeshores in Vermont (Sorenson et al. 1998) and *A. saccharinum–Carex crinita–O. sensibilis* associations in New Hampshire (Bechtel and Sperduto 1998). Type III forests correspond to the *A. saccharinum–U. americana–O. sensibilis* temporarily flooded forest community described for the Northeast (Sneddon et al. 1998).

Floodplain forest associations similar in composition to Types I, II, and III also occur on large rivers throughout the north-central United States. *Acer saccharinum* dominated forests have been described in detail in southeastern Wisconsin (Dunn and Stearns 1987; Menges 1986; Menges and Waller 1983), Ohio (Hardin et al. 1989; Hardin and Wistendahl 1983), northern Missouri (Dollar et al. 1992), New Jersey (Buell and Wistendahl 1955; Frye and Quinn 1979) and central Illinois (Brown and Peterson 1983; Peterson and Rolfe 1982). In all the forests described, *A. saccharinum* was mixed with *Fraxinus pennsylvanica* and *Ulmus americana* in the canopy, and *Laportea canadensis* was a major component of the understory.

Type IV forests are similar in vegetation composition and structure to *Quercus palustris–Fraxinus pennsylvanica* forests described in Connecticut (Metzler and Damman 1985), *Acer rubrum/Onoclea–Boehmeria* alluvial forests in Rhode Island (Barrett and Enser 1997), and *Q. palustris–A. rubrum–Carex grayi–Geum canadense* temporarily flooded forests described for New England (Sneddon et al. 1998). Type IV forests as described here differed from the above community types in having *A. saccharinum* rather than *A. rubrum* codominant with *Q. palustris* in the overstory.

Floodplain forest plots classified as Type V appeared to be seasonally saturated as indicated by prominent soil mottling close to the soil surface. Type V forests are similar in composition to *Acer rubrum–Onoclea sensibilis* forested wetlands found on poorly drained glacial lake sediments in Connecticut (Metzler and Tiner 1992) and to *A. rubrum* alluvial forests described for Massachusetts oxbows (Holland and Burk 1984). They correspond to the *A. rubrum–Fraxinus pennsylvanica* seasonally flooded forest alliance of low terraces and bottomlands occurring throughout the Eastern United States (Sneddon et al. 1998), and they are probably common in Massachusetts. *Acer rubrum* alluvial swamp forests similar to Type V forests have been described as a species-rich variant of *A. rubrum* swamps that are abundant throughout southern New England (Golet et al. 1993).

Type VI includes high floodplains that are flooded very infrequently, perhaps no more than several times per century (Jahns 1947). Type VI forests are similar in composition to high-terrace *Acer saccharum–Tilia americana–Matteuccia struthiopteris* forests in Vermont (Sorenson et al. 1998) and to high-terrace *A. saccharum–A. saccharinum–Fraxinus americana* forests in New Hampshire (Bechtel and Sperduto 1998), except that *A. saccharum* was uncommon in high-terrace plots in Massachusetts. Type VI forests are most closely related to *A. rubrum–Prunus serotina/Athyrium felix-femina* forests in New Hampshire which also had *Maianthemum canadense* and *Uvularia sessilifolia* as common associates (Bechtel and Sperduto 1998).

Vegetation patterns in relation to environmental parameters. The relationships between vegetation patterns and soil characteristics shown here are similar to those found across floodplain forest communities of the north-central United States. In New York, *Acer saccharinum–Fraxinus* sp. associations similar to Types III and IV occurred on fine-textured soils, while *Populus deltoides–Platanus occidentalis–Ulmus* sp. associations similar to Type I occurred on coarser-textured, alluvial sands and gravels (Huenneke 1982). In southern Illinois, Robertson and Weaver (1978) found that *Fraxinus pennsylvanica* attained its highest importance under prolonged and deep flooding, and occurred only at sites that had mottling near the surface. In Massachusetts, *F. pennsylvanica* attained its highest indicator values of 19 and 6 in community Types IV and V, respectively (Table 2). Results of the current study support the conclusions of Veneman and Tiner (1990) that *Boehmeria cylindrica* is restricted to hydric floodplain forest soils, while *Laportea canadensis* and *Matteuccia struthiopteris* are restricted to nonhydric soils. *Boehmeria cylindrica* was an indicator of floodplain forest community Types III, IV, and V, which occurred mainly on hydric silt loams. *Matteuccia struthiopteris* and *L. canadensis* were strong indicators of Type I and Type II, respectively, which both had predominantly coarse-textured, nonhydric soil profiles.

Soil pH was significantly different among floodplain forest community types in Massachusetts because there was a strong geographical distributional pattern among types, and soil pH appeared to be correlated with geographic location. Soils on the Connecticut, Deerfield, and Housatonic Rivers all had higher pH than those along rivers in eastern Massachusetts (Tables 3 and 4). That difference may be, in part, related to differences in flooding frequency among rivers. Dollar et al. (1992) found soil pH to be the closest correlate with variation in vegetation in northern Missouri floodplain forests and suggested that sites with higher flooding frequency and input of fresh alluvium had higher pH. This is supported in Massachusetts, where Types I, II, and III, which were located on large rivers with broad alluvial deposits (the Connecticut, Deerfield, and sections of the Housatonic Rivers), had the highest mean pH values. High pH values on the Housatonic River (pH 7–8) are also related to the influence of carbonate rich bedrock in western Massachusetts.

CONSERVATION IMPLICATIONS

Thirty-eight natural or semi-natural true floodplain forest sites (Types I–IV) ranging in size from 1 to 30 ha were identified in Massachusetts: 20 were primarily Major-river floodplain forest communities (Types I and II), 6 were Transitional (Type III), and 12 were Small-river types (Type IV). Of the 38 sites identified, only 10 were found to be high-quality examples based on their condition, size, and landscape context. The ten high-quality floodplain forests included five Major-river sites (four on the Connecticut River and one on the Housatonic River), one Transitional site on the Mill River in Hatfield, and four Small-river sites (three in the Connecticut River basin and one on the Threemile River).

With the exception of the one site on the Housatonic River, all of the high-quality examples of Major-river floodplain forests occurred on either public land or privately owned conservation land. Transitional and Small-river floodplain forests are less well-protected in Massachusetts. Due to their limited occurrence in the state and the habitat that they provide for five state-protected rare plant species, Transitional and Small-river floodplain forest communities warrant active protection efforts.

Although land acquisition and conservation restrictions are important ways to protect the remaining examples of floodplain forests in Massachusetts, land protection alone probably will not maintain these sites as high-quality, natural floodplain forest communities. Non-native taxa were present at all floodplain forest sites surveyed, and they appeared to be most prevalent in areas where the canopy was open, the herbaceous layer was cleared, and the soil was disturbed. Non-native taxa appeared to be most abundant in eastern Massachusetts and on riverine islands and riverbanks of the Connecticut River that were heavily used by campers and boaters for recreation. Long-term vegetation studies will be needed to assess the spread of non-native taxa and the impact on floodplain forest community composition and structure.

The focus of the current study was on floodplain forests within the active zone of flooding. The two other alluvial forest types identified (Type V Alluvial swamp forests and Type VI High-terrace floodplain forests) require more information to determine their distribution, vegetation composition, environmental characteristics, and quality in Massachusetts. Type V Alluvial swamp forests are probably widespread, but high-quality examples may be limited. An in-depth inventory and classification of those communities is warranted with emphasis on identifying remaining high-quality examples.

Type VI High-terrace floodplain forests are very limited in Massachusetts because most river terraces have been cleared and converted to agriculture. Some high-terrace forests occur on the Millers, Westfield, and Green Rivers and parts of the Connecticut River, but more detailed inventories and vegetation and environmental analyses are warranted.

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